# THE JENSA GAS JET TARGET

## MOTIVATION

We need improvements in beams, targets, and detector systems in order to continue to push the frontiers of nuclear physics

The Jet Experiments in Nuclear Structure and Astrophysics (JENSA) Collaboration has designed, constructed and characterized a cutting-edge gas jet target for use in the next generation of nuclear physics experiments

Table 5: Comparison of the maximum reported areal densities, in units of $10^{18}$ atoms/cm$^2$, achieved by similar existing gas jet targets, as well as a benchmark to a $CH_2$ solid foil target.

| Reference | $N_2$ | He | $H_2$ |
|---|---|---|---|
| 100 $\mu$g/cm$^2$ $CH_2$ solid target | - | - | $\sim 8-9$ |
| Erlangen (now at TUNL) [5] | $\sim 22^a$ | not reported | $\sim 9^a$ |
| Frankfurt [15] | $\sim 7.3^b$ | not reported | not reported |
| Munster [13] | $0.34 \pm 0.06$ | $0.4 \pm 0.06$ | $0.33 \pm 0.07^c$ |
| RHINOCEROS [14] | not reported | $\sim 0.08^d$ | not reported |
| HIPPO [12] | $0.535 \pm 0.032$ | $0.283 \pm 0.04$ | not reported |
| JENSA$^e$ (Jet Nozzle A) | $9.11 \pm 0.21$ | $5.76 \pm 0.46$ | $\sim 8^f$ |
| JENSA$^e$ (Jet Nozzle B) | $11.51 \pm 0.50$ | $10.19 \pm 0.85$ | |

$^a$ Calculated based on the reported maximum mass densities of 0.5 mg/cm$^2$ for nitrogen and 15 $\mu$g/cm$^2$ for hydrogen; however, these were achieved with a cylindrical and not Laval jet nozzle, so while the maximum density was higher (by a factor of two or more [5]), the uniformity was lower

$^b$ Calculated based on the reported maximum mass density of 170 $\mu$g/cm$^2$

$^c$ Reported value for deuterium gas

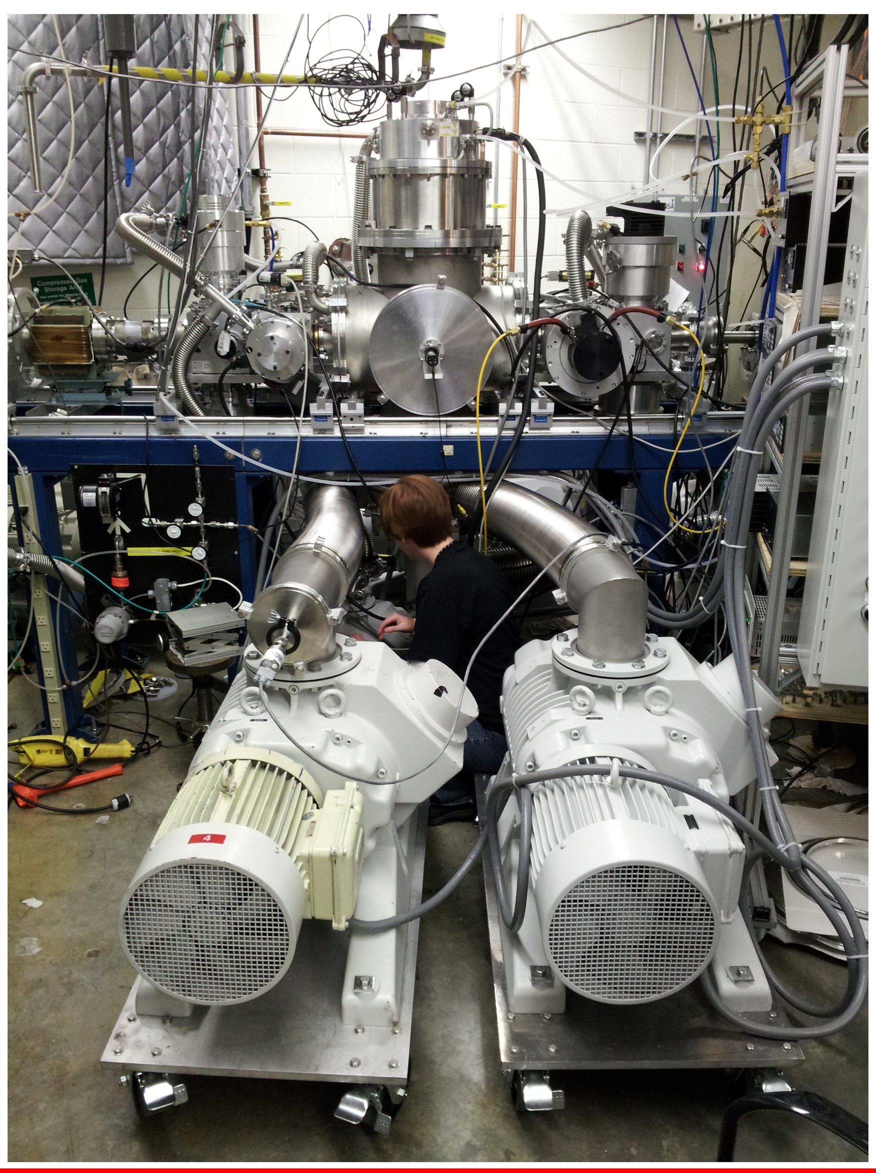
$^d$ Calculated based on the reported calculated volumetric density of $3 \times 10^{17}$ atoms/cm$^3$ and jet size of $2.6 \pm 0.2$mm; experimental values for the volumetric density of helium are not given. Ref. [14] also report a measured neon jet density of $2.4 \times 10^{17}$ atoms/cm$^2$, lower than the JENSA target

$^e$ Maximum measured densities for $N_2$ and He are reported; higher densities should be achievable but were not tested due to time constraints

$^f$ Anticipated performance

## TAKE-HOME MESSAGE

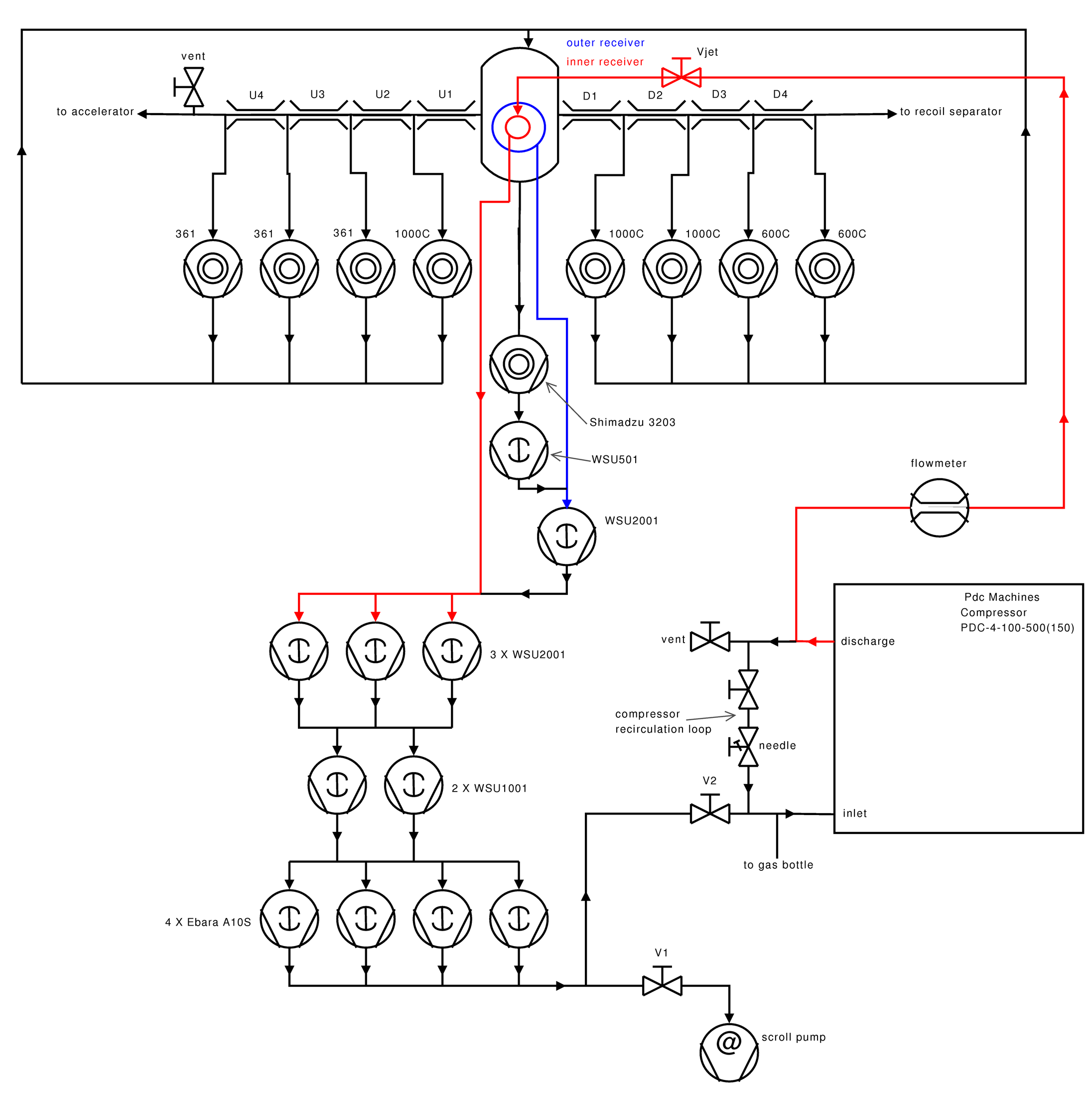
The JENSA gas jet target is the most dense helium jet for RIB studies in the world

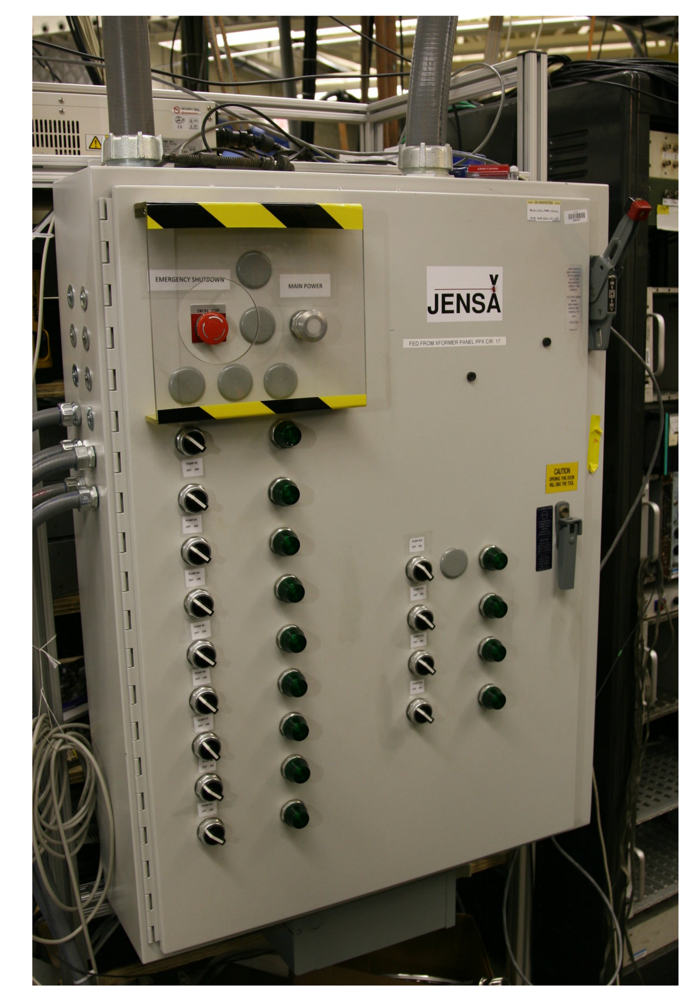


## SYSTEM CONFIGURATION

*Left: Photograph of a portion of the JENSA gas jet system.*

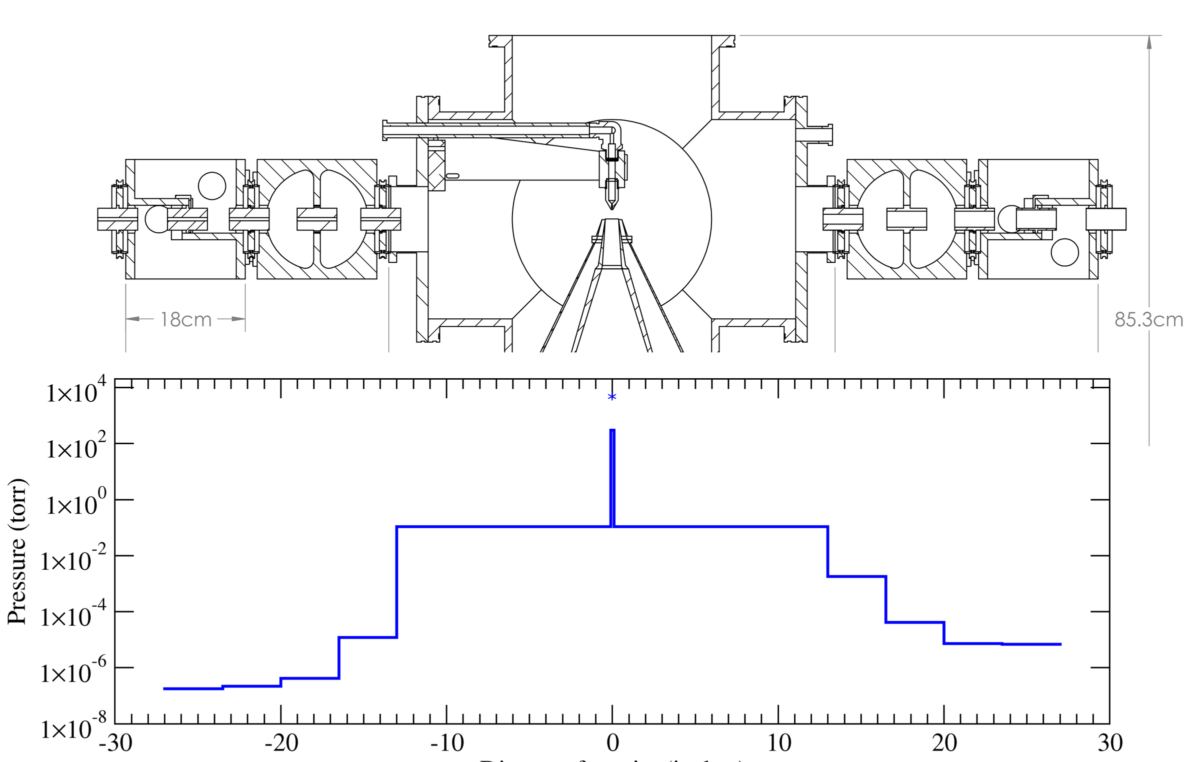
*Right: Pumping schematic for the JENSA gas jet target system. Gas flow from the inner receiver nozzle and from the high-pressure discharge of the compressor to the Laval nozzle is shown in red, and gas flow from the outer receiver nozzle is shown in blue. Vacuum pressure gauges, which are located at strategic points around the system, are not shown to avoid cluttering. Not all valves are displayed for the same reason. The restrictive apertures between pumping stages are shown as "throttling" elements and labeled U1-U4 (upstream) and D1-D4 (downstream). Pump types are labeled (pumps are Leybold unless otherwise noted).*



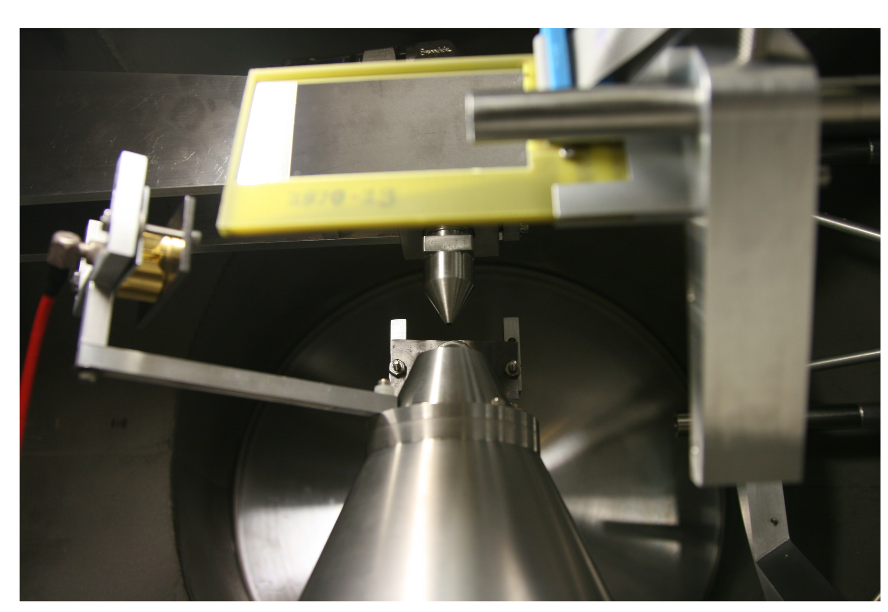



*Above: Control panel for the JENSA system roots blowers*

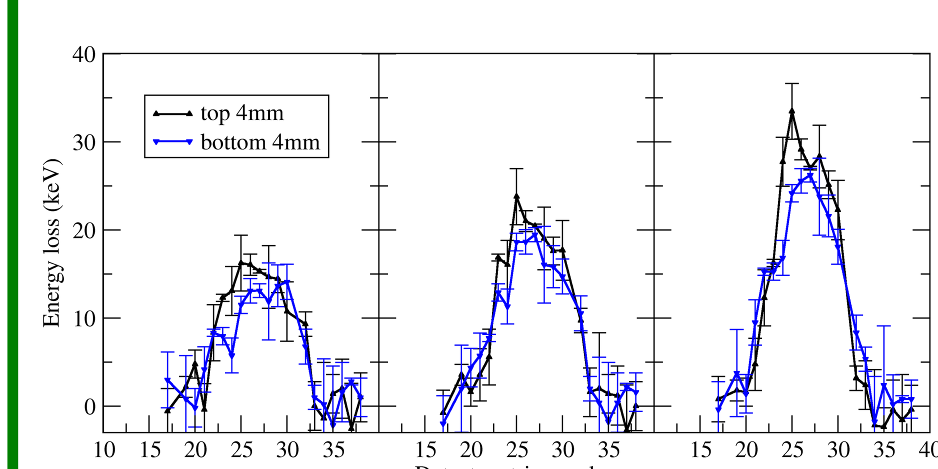
## PRESSURE PROFILES

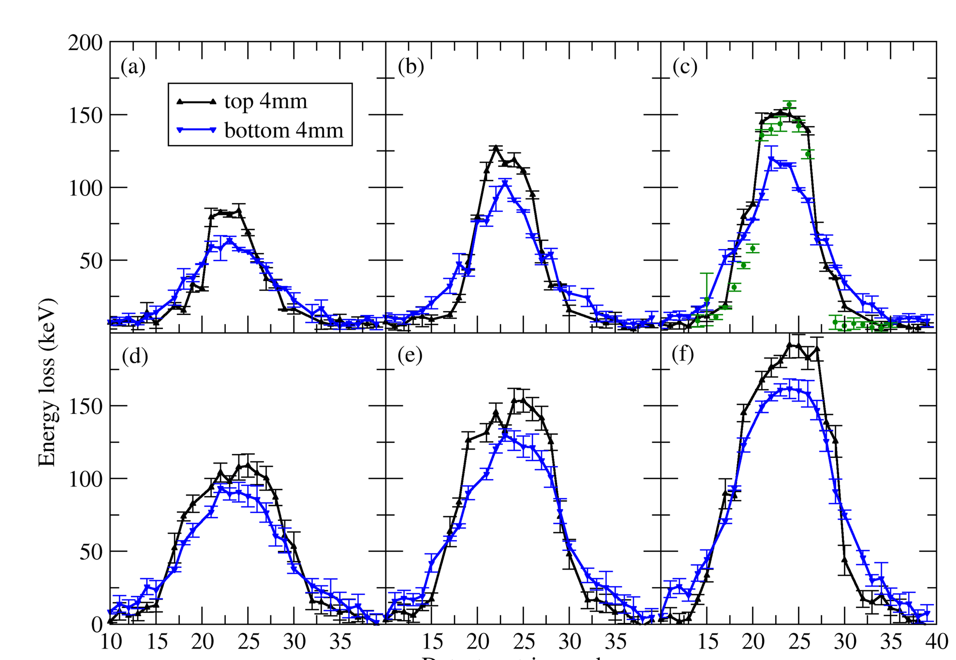



*Pressure profile as measured along the JENSA gas jet target system, overlaid with a CAD drawing of the JENSA components for comparison. The blue star at the jet location shows the measured pressure at the inlet of the jet nozzle; the solid blue curve at the jet location shows the derived pressure of the jet after expansion into the chamber (in other words, as "seen" by a beam). Note the log scale on the vertical axis.*



*Jet profiles, created by imaging energy loss of an alpha source versus position on a highly-segmented silicon detector (left), of helium (below left) and nitrogen (below) for 200, 300, and 400psi inlet pressure. Black curves show the top of the jet, and blue curves show the bottom of the jet. The helium and top panels of nitrogen were performed with a 0.8mm neck nozzle, creating a 4mm wide jet; the bottom panels of nitrogen used a 1.1mm neck nozzle, creating a 5mm wide jet..*




## "IMAGING" THE GAS JET

## JET DENSITIES

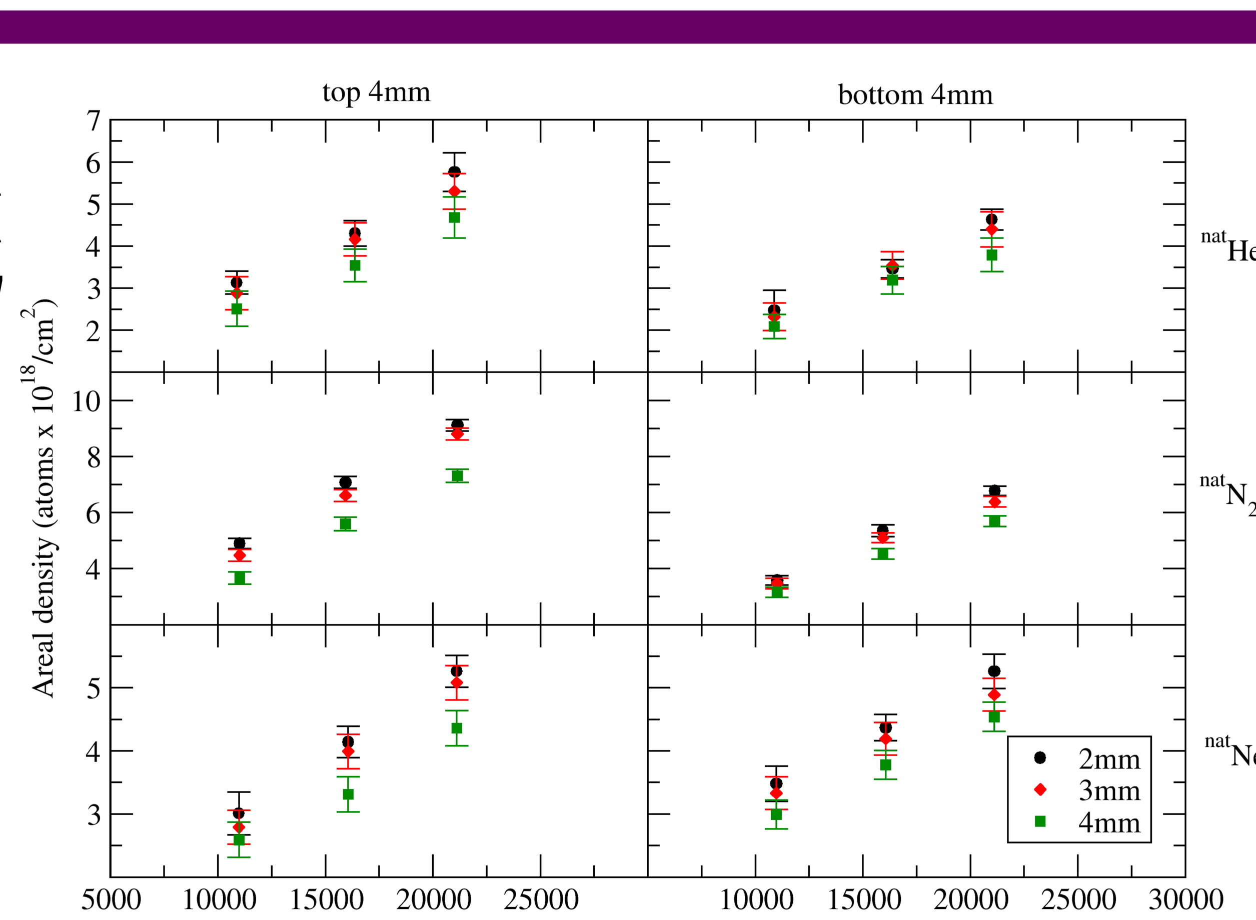
*Jet areal densities were derived from the energy loss measurements via measured stopping powers. Densities are shown for several gas species, jet inlet pressures, and partial jet widths.*

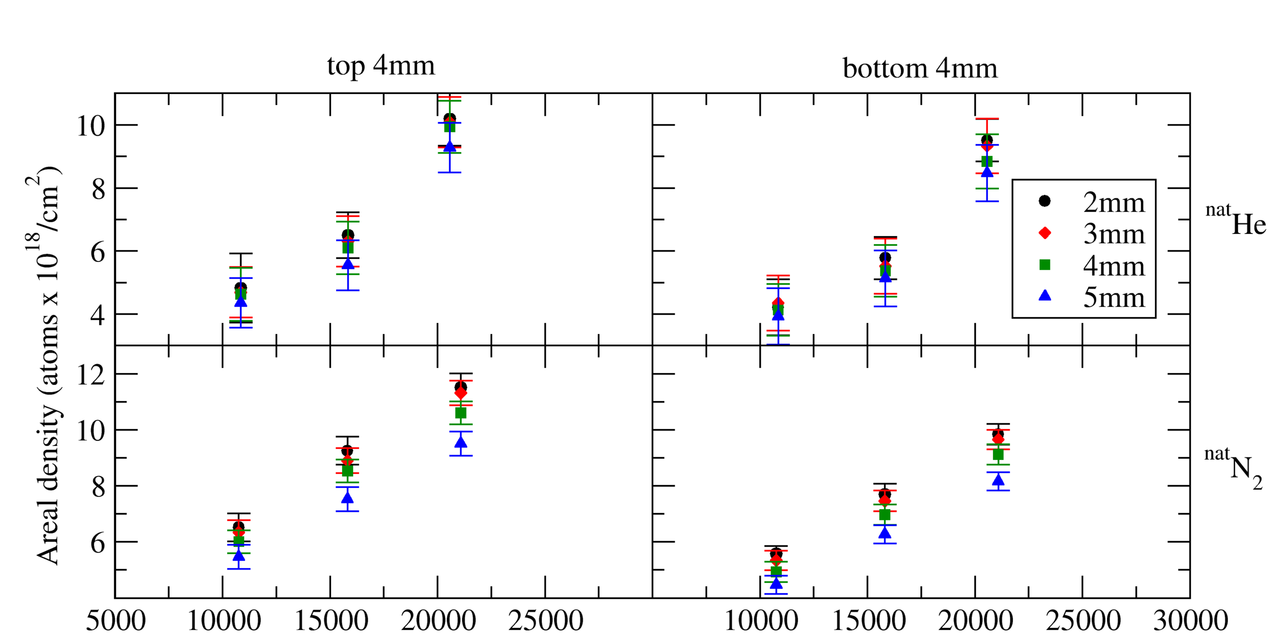
Table 4: Relationship of jet areal density to jet inlet pressure for the jet nozzles and gas species tested, for the purposes of estimating jet density. Values are given for the average areal density over the width of the jet; for Jet Nozzle A, the width is 4mm, and for Jet Nozzle B, the width is 5mm. These linear fits can be used to calculate the density of a jet of any pressure within the normal operational parameters of the JENSA system, to within 5-10%. If the orientation of the jet nozzle and receivers is the same as in the ORNL commissioning setup, the density for the "top" of the jet should be adopted, as this is what aligns with the beam axis.

| Gas | Jet Nozzle | Vertical position | Slope$^a$ | Intercept$^b$ |
|---|---|---|---|---|
| Ne | A | top | 0.17 | 0.09 |
| | A | bottom | 0.15 | 0.05 |
| $N_2$ | A | top | 0.35 | -0.04 |
| | A | bottom | 0.27 | 0.07 |
| | B | top | 0.45 | 0.21 |
| | B | bottom | 0.39 | 0.10 |
| He | A | top | 0.22 | 0.02 |
| | A | bottom | 0.18 | 0.05 |
| | B | top | 0.43 | -0.23 |
| | B | bottom | 0.39 | -0.22 |

$^a$ Units of atoms/cm$^2$/kTorr

$^b$ Units of atoms/cm$^2$




The JENSA Collaboration is made up of researchers from several different universities and national laboratories across the US, including: the Colorado School of Mines, Oak Ridge National Laboratory, Louisiana State University, University of Notre Dame, Michigan State University/National Superconducting Cyclotron Laboratory, and the University of Tennessee Knoxville

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